Designing fiscal and monetary institutions for a European Monetary Union

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ABSTRACT:

This paper explores under what conditions a European Monetary Union (EMU) is an optimum currency area. The scope for an EMU increases with convergence of structural and fiscal policies, small money holdings, a conservative European Central Bank, and dependent national central banks. How national policies affect the rest of the union once the EMU has been formed is also investigated. The case for surveillance of national structural and fiscal policies appears to depend largely on monetary arrangements in the union.

Keywords: European Monetary Union, European Central Bank, (optimal) institutions, inflation aversion, convergence, structural policies.

JEL Codes: E52, E58, E61, E62, F42.

October 1995

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* We thank seminar participants at DELTA (Paris) and CentER (Tilburg) for their helpful comments. This paper was written while Beetsma was a postdoctoral fellow at DELTA (Joint Research Unit CNRS-EHESS-ENS). He thanks DELTA for the stimulating research environment.

1. Introduction

The Maastricht Treaty, which is based on the Delors Report (1989), formulates the institutional framework in which a common monetary policy and national fiscal policies are to be conducted within a European Monetary Union (EMU). In particular, the European Central Bank (ECB) is modelled after the Bundesbank: it should be independent from fiscal policymakers while its primary objective should be to guarantee price stability. Furthermore, countries desiring to enter the EMU should meet certain convergence criteria involving public debt levels and fiscal deficits. After joining the union, member countries should subject their fiscal policies to surveillance by the European Commission.[1]

A number of academics have criticized the fiscal convergence criteria (e.g., Buiter and Kletzer, 1990, and Bean, 1992). Others maintain that surveillance of national policies within the EMU is not necessary because financial markets will discipline national fiscal policies. Moreover, the crowding out effect of domestic public debt on private investment in other members of the union appears to be of only minor importance (see, e.g., Levine and Brociner (1994)).

This paper explores the rationale for constraints on national policies from the point of view of the strategic interaction between monetary and fiscal policymakers. Our analysis incorporates several channels through which national fiscal policies interact with the common monetary policy in an EMU.[2] In particular, by generating seigniorage, monetary policy impacts the public finances directly. Moreover, surprise inflation can help tax and structural policies in boosting employment and output. We focus on a second-best world where fiscal authorities need to rely on distortionary taxation and where monetary authorities lack commitment. Our analysis reveals that such an imperfect world provides a case for both entrance criteria involving the convergence of fiscal policies and surveillance of national policies once the union has been formed. In fact, for a monetary union to be in the interests of all member countries, not only fiscal policies but also structural policies and labor market institutions should converge.

In stressing the need for convergence in fiscal and structural policies, we extend the literature on optimum currency areas. Whereas the traditional literature emphasizes barriers to international factor mobility and international trade and lack of diversification in trade as obstacles to a monetary union (see e.g., Mundell, 1961; McKinnon, 1963; Kenen, 1969),[3] we focus on international differences in monetary and labor-market institutions as well as public spending needs. Our analysis reveals that the size of an optimum currency area depends on the initial position of

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[1] Recent overviews on European monetary unification can be found in Bean (1992) and Eichengreen (1993).

[2] For the interaction between monetary and fiscal policies in a closed economy, Tabellini (1986), Alesina and Tabellini (1987), Levine and Pearlman (1992), Levine (1993), Debelle (1993), Debelle and Fischer (1994), Levine and Brociner (1994) and Krichel, Levine and Pearlman (1994).

[3] For more recent work on currency areas in this tradition, see, e.g., Mélitz (1993) and Bayoumi (1994).

the central bank vis-à-vis the government, the degree of conservatism of the European Central Bank (ECB), the importance of seigniorage and differences in structural policies (public indebtedness, labor market flexibility and the efficiency of the tax system) as reflected in the so-called government financing requirement. In particular, if national monetary arrangements are optimal, an EMU is feasible only if the government financing requirements are identical in all participating countries. The scope for an EMU becomes larger if money holdings are small and, in contrast to the national central banks, the ECB can be made more conservative than society (in the sense that it attaches a high priority to price stability). Intuitively, in this case, a conservative ECB can substantially improve the price-stability performance of a national central bank. The associated efficiency gains offset the costs associated with a union-wide monetary policy that can no longer be attuned to country-specific circumstances. In this way, a more conservative central bank takes away the need to impose severe restrictions on fiscal and structural policies. Indeed, there is a trade-off between, on the one hand, designing the proper monetary institutions within the EMU, and, on the other hand, requiring more convergence in other areas of economic policy.

Besides exploring entrance criteria into the EMU, the second main purpose of the paper is to study the externalities associated with national policies once an EMU has been established and individual participants can no longer be forced to comply with the entrance requirements. These spillovers provide a case for surveillance of national policies. We find that the most disciplined countries with relatively small financing requirements (i.e. countries with flexible labor markets and efficient tax systems) suffer most from the lack of discipline in other countries. These countries, therefore, are most interested in the European Commission conducting strict surveillance of national policies in other countries. However, a conservative ECB may substitute for this surveillance; if the ECB is sufficiently conservative, these countries do not suffer first order welfare losses from less disciplined policies abroad. Indeed, adverse spillovers of fiscal and structural policies originate in monetary distortions. Hence, surveillance of these policies acts as an indirect instrument to deal with the imperfect conduct of monetary policy.

The remainder of this paper is as follows. Section 2 sets out the model while Section 3 presents the equilibrium policy outcomes. In analyzing the conditions under which an EMU is an optimum currency areas, Section 4 deals with the entrance requirements for an EMU. The case for surveillance is investigated in Section 5, which explores the externalities once an EMU has been formed. Section 6 concludes the paper by summarizing the main policy conclusions.

2. The model

The EMU consists of n potentially participating countries. Commodities are tradable and perfect substitutes, so that the inflation rate (determined by the ECB; see below) is the same across the whole union. Moreover, capital is perfectly mobile between countries, while labor is immobile

internationally.[4]

Consider some country, say i (i=1,..,n). Following, among others, Alesina and Tabellini (1987), Debelle (1993), Jensen (1994) and Beetsma and Bovenberg (1995), we assume that workers are represented by trade unions whose sole objective is to achieve a target real wage rate, the logarithm of which we normalize to zero. Therefore, the (log) of the nominal wage rate is set equal to the (rationally) expected (log) price level, p^e. Nominal wage contracts are signed before policy is selected. Accordingly, unions act as Stackelberg leaders vis-à-vis the authorities.

Output of a representative firm is $Y_i = L_i^{\eta}$, where L_i is labor, and is taxed at a rate τ_i. The firm maximizes profits $PL_i^{\eta}(1-\tau_i)-WL_i$, where P and W represent the price level and the wage rate (which is uniform across the entire union, because the expected price level inflation is uniform across the union). Hence, (log) output is given by $y_i = (\eta/(1-\eta))(\pi-\pi^e-\tau_i+\log\eta)$, where π denotes the inflation rate and π^e the expected inflation rate. For convenience, we normalize output by subtracting the constant $(\eta/(1-\eta))\log\eta$ from y_i. Without any consequences for our main results, we set $\eta=½$, so that normalized output, x_i, amounts to

$$x_i = \pi-\pi^e-\tau_i \tag{2.1}$$

Without tax distortions, $x_i=0$ in a rational expectations equilibrium (where $\pi=\pi^e$, see (2.1)). In addition to distortionary output taxes, we allow for other, non-tax, distortions due to, for example, union power in the labor market or monopoly power in commodity markets. The first-best output level, i.e. output with neither tax nor non-tax distortions, is denoted by $\tilde{x}_i$. Thus, $\tilde{x}_i>0$ measures the non-tax distortions and can be interpreted as an *implicit* tax on output. In fact, an output subsidy can offset the implicit output tax ($\tau_i=-\tilde{x}_i$), thereby raising output to its non-distortionary level $\tilde{x}_i$.

Society i's welfare function differs from that of the unions, because it accounts for the preferences of not only workers but also non-workers. Society i's preferences, which are defined over consumer price inflation, output and public spending, are represented by the following loss function:

$$V_{S,i} = ½\,[\alpha_{\pi S}\,\pi^2 + (x_i-\tilde{x}_i)^2 + \alpha_{gS}\,(g_i-\tilde{g}_i)^2],\ \alpha_{\pi S},\alpha_{gS}>0. \tag{2.2}$$

Welfare losses increase in the deviations of inflation, (log) output and government spending (g_i is government spending as a share of non-distortionary output) from their targets.[5] The target level of

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[4] It is well known that labor is relatively immobile in Europe (for example due to linguistic, cultural, social and institutional barriers).

[5] Employment and output are directly related through the production function. Hence, instead of output, employment could have been included in the objective functions, with the target employment level corresponding to the employment level in absence of any distortions.

inflation corresponds to price stability while the target for output is given by its non-distortionary level, $\tilde{x}_i$. The target for government spending, $\tilde{g}$, can be interpreted as the optimal share of non-distortionary output to be spent on public goods if (non-distortionary) lump-sum taxes would be available (Debelle and Fischer, 1994; Beetsma and Bovenberg, 1995). Parameters $\alpha_{\pi S}$ and α_{gS} stand for the weights of the inflation and government spending objectives, respectively, relative to the weight of the output objective, which we have normalized to unity. Only relative preference weights matter for the outcomes. In the limiting case of $\alpha_{gS}\rightarrow\infty$, the government spending share is set exogenously at $\tilde{g}_i$.

All countries attach the same relative preference weights to inflation[6] and public spending. Targets for employment and public spending, in contrast, are allowed to vary across countries. Differences in target levels for output and employment may reflect international diversity in labor market institutions. Differences in the targets for public spending indicate diverging preferences for public goods.

3. Equilibrium policies and welfare under an EMU

Beetsma and Bovenberg (1995) study the case where monetary policy is decided at the national level. The first-best equilibrium is reached if a single benevolent policymaker, who controls both fiscal and monetary policy, can freely use lump-sum taxation. If this policymaker has to resort to distortionary taxation because of limited access to lump-sum taxes, the resulting equilibrium is second best. The absence of commitment results in additional welfare losses as the policymaker is tempted to use unanticipated inflation as an indirect instrument to alleviate tax distortions by raising employment. In this case, decentralizing monetary policy to an independent central bank, which does not take into account the government budget constraint, can be welfare improving. Intuitively, the failure to internalize the government budget constraint offsets the self-defeating incentive to use unanticipated inflation to boost employment.

In an EMU, the ECB selects the common inflation rate for the entire region. The preferences of the ECB are given by

$$V_{ECB} = \tfrac{1}{2}\{\alpha_{\pi M}\pi^2 + \textstyle\sum_{i=1}^{n}[(x_i-\tilde{x}_i)^2+\alpha_{gS}(g_i-\tilde{g}_i)^2]/n\},\ \alpha_{\pi M}>0, \qquad (3.1)$$

where the inflation weight, $\alpha_{\pi M}$, is allowed to differ from societies' inflation weight, $\alpha_{\pi S}$.[7] The ECB equally weights the interests of all countries. In fact, if $\alpha_{\pi M}=\alpha_{\pi S}$, the objective function of the ECB is an equally weighted average of the individual societies' objective functions. We assume that the

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[6] Alesina and Grilli (1992, 1993) analyze the design of an ECB and the feasibility of an EMU while allowing for different degrees of inflation aversion across countries.

[7] As first pointed out by Rogoff (1985), society may want to appoint a central banker with preferences that differ from society's preferences. See also below.

ECB is not able commit to its policy announcements. Hence, it minimizes (3.1) subject to (2.1), i=1,..,n , taking as given tax rates, public spending ratios as well as the expected inflation rate, π^e. The resulting reaction function amounts to

$$\pi = \left(\frac{1}{\alpha_{\pi M}+1}\right)\left(\pi^e+\frac{1}{n}\sum_{i=1}^{n}\left(\tau_i+\tilde{x}_i\right)\right). \tag{3.2}$$

Larger (tax and non-tax) distortions in output and labor markets in any of the participating countries or higher expected inflation induce the monetary authority to raise inflation in order to protect employment.

Fiscal policy continues to be conducted at the national level. Country i's government faces the following budget constraint[8]

$$g_i + (1+\rho)\, d_i = \tau_i + \kappa\pi + \theta_i\,, \tag{3.3}$$

where ρ denotes the constant real interest rate and $d_i \geq 0$ represents the stock of single-period indexed government debt (expressed as shares of non-distortionary output). The government can employ only a limited, exogenous amount of lump-sum taxation, which as a share of non-distortionary output equals θ_i. $\kappa \geq 0$ stands for the constant ratio of real money holdings and non-distortionary output.[9] Seigniorage revenues are represented by $\kappa\pi$ as all countries receive an equal share of the seigniorage revenues acquired by the ECB.

We can write the government budget constraint (3.3) as follows:

$$\mathbb{K}_i \equiv \tilde{g}_i + (1+\rho)d_i + \tilde{x}_i - \theta_i = [\tau_i+\tilde{x}_i] + \kappa\pi + [\tilde{g}_i-g_i]. \tag{3.4}$$

where $\mathbb{K}_i$ is the *government financing requirement* (see Beetsma and Bovenberg, 1995), which amounts to the government spending target $\tilde{g}_i$, debt servicing costs, $(1+\rho)d_i$, and a labor subsidy aimed at offsetting the implicit tax on output, $\tilde{x}_i$, net of the maximum amount of lump-sum taxes, $\theta_i < \tilde{g}_i+(1+\rho)d_i+\tilde{x}_i$. The last right-hand side of (3.4) represents the sources of finance: explicit and implicit tax revenues, $\tau_i+\tilde{x}_i$, seigniorage revenues, $\kappa\pi$, and the shortfall of government spending from its target, $\tilde{g}_i-g_i$.

The government of country i selects the distortionary tax rate, τ_i, and the public spending ratio, g_i, to minimize the social welfare loss (2.2) subject to (2.1) and (3.3). The associated Lagrangian is

$$\pounds = \tfrac{1}{2}\{\alpha_{\pi S}\pi^2+(\pi-\pi^e-\tau_i-\tilde{x}_i)^2+\alpha_{gS}(g_i-\tilde{g}_i)^2\} + \lambda[g_i+(1+\rho)d_i-\tau_i-\kappa\pi-\theta_i], \tag{3.5}$$

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[8] The government budget constraint is derived in Appendix A of Beetsma and Bovenberg (1995).

[9] Alesina and Tabellini (1987), Debelle (1993), Debelle and Fischer (1994) and Jensen (1994), among others, assume that $\kappa=1$. However, as will become clear below, the value of κ plays an important role in our analysis.

where (2.1) has been used to eliminate x_i and where λ denotes the Lagrange multiplier of the budget constraint of government i. Optimization yields the following reaction functions for τ_i and g_i:

$$\tau_i+\tilde{x}_i+\pi^e-\pi = \left(\frac{1}{1+\alpha_{gS}^{-1}}\right)\left(\tilde{K}_i-\kappa\pi+(\pi^e-\pi)\right), \quad i=1,..,n, \tag{3.6}$$

$$\tilde{g}_i-g_i = \left(\frac{\alpha_{gS}^{-1}}{1+\alpha_{gS}^{-1}}\right)\left(\tilde{K}_i-\kappa\pi+(\pi^e-\pi)\right), \quad i=1,..,n. \tag{3.7}$$

To interpret the reaction functions, we rewrite the government budget constraint as $[K_i+(\pi^e-\pi)-\kappa\pi] = [\tau_i+\tilde{x}_i+\pi^e-\pi] + [\tilde{g}_i-g_i]$. The left hand side of the equation, which appears at the right-hand sides of both (3.6) and (3.7), represents the *residual* government financing requirement of the fiscal authorities, i.e. the financing requirement left for the fiscal authorities after taking into account seigniorage and the impact of inflation surprises (i.e. $\pi^e-\pi$) on output. If $\alpha_{gS}\to\infty$, the entire burden of residual finance falls on taxes as government spending is fixed at $\tilde{g}$.

Inflation, taxes and public spending

Imposing rational expectations (i.e. $\pi=\pi^e$) and solving (3.2), (3.6) and (3.7), we arrive at the equilibrium policy outcomes,

$$\kappa\pi = \left(\frac{\frac{\kappa}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\tilde{K}_i - \left(\frac{\frac{\kappa}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\left(\tilde{K}_i-\tilde{K}_A\right) = \left(\frac{\frac{\kappa}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\tilde{K}_A, \tag{3.8}$$

$$\tau_i+\tilde{x}_i = \left(\frac{1}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\tilde{K}_i + \left(\frac{1}{1+\alpha_{gS}^{-1}}\right)\left(\frac{\frac{\kappa}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\left(\tilde{K}_i-\tilde{K}_A\right), \tag{3.9}$$

$$\tilde{g}_i-g_i = \left(\frac{\alpha_{gS}^{-1}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\tilde{K}_i + \left(\frac{\alpha_{gS}^{-1}}{1+\alpha_{gS}^{-1}}\right)\left(\frac{\frac{\kappa}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\left(\tilde{K}_i-\tilde{K}_A\right), \tag{3.10}$$

where K_A denotes the average government financing requirement. With uniform financing requirements (i.e. $K_A=K_i$), the outcomes are the same as in an economy where monetary policy is

selected by a national, independent central bank with the inflation weight $\alpha_{\pi M}$ and which is involved in a Nash game with the fiscal authority (see Beetsma and Bovenberg 1995). In a country featuring a lower than average financing requirement (i.e. $\tilde{K}_i<\tilde{K}_A$), inflation and public spending are higher while taxes are lower than under a national central bank. Intuitively, in a monetary union with a relatively large average financing requirement, high output taxes and substantial labor-market distortions reduce average employment and output. Accordingly, the common central bank is tempted to set a high inflation rate to stimulate employment. The additional seigniorage revenues associated with the higher inflation rate allow all member countries, including the ones with a relatively low financing requirement, to cut output taxes and raise spending.

Welfare

Society i's welfare loss can be written as,

$$V_i^E = V_i^N + \left(\frac{\frac{\kappa}{\alpha_{\pi M}} - \frac{\alpha_{\pi S}}{\alpha_{\pi M}^2}}{N_D^2} \right) \tilde{K}_i\left(\tilde{K}_i - \tilde{K}_A\right) + \left(\frac{\frac{\alpha_{\pi S}}{\alpha_{\pi M}^2} + \frac{\kappa^2}{\alpha_{\pi M}^2\left(1+\alpha_{gS}^{-1}\right)}}{2N_D^2} \right) \left(\tilde{K}_i - \tilde{K}_A\right)^2, \tag{3.11}$$

$$\text{where } V_i^N \equiv \left(\frac{\frac{\alpha_{\pi S}}{\alpha_{\pi M}^2} + 1 + \alpha_{gS}^{-1}}{2N_D^2} \right) \tilde{K}_i^2 \ , \ N_D \equiv 1 + \frac{\kappa}{\alpha_{\pi M}} + \alpha_{gS}^{-1}.$$

V_i^N stands for the welfare loss if monetary policy is conducted at the national level by an independent central bank with inflation weight $\alpha_{\pi M}$ and which is involved in a Nash game with the fiscal authority.

With national monetary policymaking, the optimal inflation weight of the national central bank is given by $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$ (see Beetsma and Bovenberg 1995). At that inflation weight, the second term at the right-hand side of (3.11) is zero. Accordingly, losses in a monetary union exceed those with national monetary policy unless the national financing requirement happens to coincide with the average (i.e. $\tilde{K}_i=\tilde{K}_A$). Intuitively, from the perspective of an individual country, the common central bank sets a sub-optimal inflation rate because it looks at the average rather than the country-specific financing requirement in deciding on the community-wide inflation rate.

If the national central bank is not conservative enough (i.e. $\alpha_{\pi M}<\alpha_{\pi S}/\kappa$), however, a country with a larger than average financing requirement may gain from entering a monetary union with a central bank featuring the same price-stability weight as the national central bank (for such a country the second term at the right-hand side is negative). The reason is that national policymaking produces an excessively high inflation rate. Entrance into a monetary union with a relatively low average financing requirement reduces the inflation rate, thereby moving closer to the

second-best optimum. Intuitively, the failure of the common central bank to attune its monetary policy to the country-specific financing requirement offsets the distortion in monetary policy due to the absence of commitment.

4. When is the EMU an optimum currency area?

This section explores conditions under which an EMU is an optimum currency area. The traditional literature on optimum currency areas deals with international factor mobility, the openness of economies to international trade and diversification in trade (see e.g. Mundell, 1961; Mckinnon, 1963; Kenen, 1969). We, in contrast, emphasize convergence of fiscal and structural policies related to international differences in labor-market institutions and public-spending objectives. Indeed, monetary policy is related to fiscal and structural policies through various channels. In particular, monetary policy impacts the public finances by generating seigniorage. Moreover, in achieving employment objectives, unanticipated inflation can aid tax and structural policies in boosting output.

In this section, we explore whether the EMU can be Pareto-welfare improving in the sense that none of the n potential participants lose when compared to the national monetary policymaking. This implies that the optimum currency area consists of those countries that benefit from community-wide decisionmaking on monetary policy. Optimality is defined within the context of the current model. In particular, to sharpen the focus on fiscal and structural policies, we ignore possible other advantages of an EMU. We abstract also from transfer payments between countries.

We explore various ways to extend the union to more countries, including entrance requirements involving the convergence of fiscal and structural policies. Furthermore, we investigate the role of monetary policy institutions and, in particular, the weight the ECB attaches to price stability.

Monetary arrangements optimal outside the EMU

The trade-off of the fiscal authorities between taxes and public spending implied by (3.6) and (3.7) is optimal from a social perspective. Hence, in order to assess whether a country profits from entering EMU, we have to compare only deviations of the inflation rate from the second-best inflation rate before and after entering the union (see also Appendix A). If the national central bank (which is involved in a Nash game with the fiscal authority) attaches the optimal weight to price stability (the optimal weight with national policymaking is $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$, see Beetsma and Bovenberg, 1995), it sets the optimal inflation rate. Hence, country i enters the EMU only if the union delivers the same inflation rate:

$$\left(\frac{\frac{1}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\left(\frac{\tilde{K}_A}{\tilde{K}_i}\right) = \left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right), \tag{4.1}$$

where the right-hand side is the optimal inflation rate (divided by K_i) from society i's perspective (see Beetsma and Bovenberg, 1995). Hence, for country i to be willing to participate, the price-stability weight of the ECB should be (see Appendix B):

$$\alpha_{\pi M,i}^{opt} \equiv \frac{\alpha_{\pi S}}{\kappa}\left(1 + \left(\frac{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}{1+\alpha_{gS}^{-1}}\right)\left(\frac{\tilde{K}_A-\tilde{K}_i}{\tilde{K}_i}\right)\right). \tag{4.2}$$

This price stability weight depends on the size of i's government financing requirement relative to the average financing requirement. In particular, if country i is 'disciplined' in the sense that it features a relatively low financing requirement, it prefers a rather 'conservative' ECB, which attaches a relatively high priority to price stability (i.e. more priority than would be optimal outside the union, $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$). The reason is that the ECB selects the inflation rate on the basis of the average rather than the country-specific financing requirements. Consequently, from the point of view of countries with relatively low financing requirements, the ECB tends to set an inflation rate that is too high. To offset this tendency, the ECB should be made more adverse against inflation.

Expression (4.2) indicates that countries disagree on the optimal price-stability weight if financing requirements diverge. Hence, even if the price-stability weight of the ECB can be selected freely, a monetary union is feasible only if financing requirements coincide. The formal entrance requirements of the EMU emphasize convergence in public debt and fiscal deficits. Our analysis indicates, however, that the EMU requires convergence not only in public debt but also in labor market institutions and government spending.

Monetary arrangements suboptimal outside and inside the EMU

The scope for a monetary union may seem potentially greater if the inflation rate is sub-optimal before a country enters the union. This is generally so if the national, independent Central Bank features the same price-stability weight as society and is involved in a Nash game with the government (see Beetsma and Bovenberg, 1995). In that case, country i enters the EMU if after joining inflation would be at least as close to the optimal inflation rate as before joining the union:

$$\left(\left(\frac{\frac{1}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\left(\frac{\tilde{K}_A}{\tilde{K}_i}\right)-\left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)\right)^2 \leq \left(\left(\frac{\frac{1}{\alpha_{\pi S}}}{1+\frac{\kappa}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)-\left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)\right)^2, \qquad (4.3)$$

where the first term on the right hand side is the inflation rate (divided by $\tilde{K}_i$) resulting from the Nash game between the government and a national central bank with price-stability weight $\alpha_{\pi S}$.

Suppose first that $\alpha_{\pi M}=\alpha_{\pi S}$ so that the ECB's inflation weight coincides with societies' and thus the pre-reform central banks' inflation weight. In that case, just as with optimal monetary arrangements, an EMU is feasible only if financing requirements of all countries participating in the union coincide. We can explain this by distinguishing two cases depending on real money holdings. If $\kappa<1$, the countries with a lower than average financing requirement would be worse off inside a union than outside it. The reason is that before entering the union inflation is already too high from a social point of view. By joining countries with a higher financing requirement, the common central bank is tempted to push inflation even higher, thereby diverging even further from the optimum. If $\kappa>1$, in contrast, inflation is too low because the central bank does not take into account the value of seigniorage to budget.[10] In that case, countries featuring a financing requirement above average suffer from entering the union; by merging with a group of countries with lower financing requirements inflation falls further below the optimum.

Monetary arrangements suboptimal outside the EMU

The benefits of the union are potentially greater if, in contrast to the preferences of the independent national central banks (involved in a Nash game with the fiscal authority), the preferences of an international institution like the ECB, which is further removed from domestic political pressures, can be made to differ from those of society. In that case, perfect convergence in financing requirements is generally not required to make the EMU possible. Intuitively, the benefits associated with moving towards better monetary arrangements under EMU offset the costs associated with one union-wide inflation rate that is not attuned to the specific circumstances of each country. To show this, we rank the government financing requirements in their order of magnitude, so that $\tilde{K}_1 \leq \tilde{K}_2 \leq .. \leq \tilde{K}_n$. For $\kappa \geq 1$, the maximum ratio of the largest and the smallest government financing requirement that is still compatible with the existence of a price-stability weight of the ECB under which all countries benefit from entering the union is (see Appendix C):

[10] If $\kappa=1$, inflation would be optimal outside the union. Entrance to the union would make all countries worse off unless their financing requirements would coincide with the average financing requirement.

$$\left(\frac{\tilde{K}_n}{\tilde{K}_1}\right)^{max} = \left(\frac{(2\kappa-1)(1+\alpha_{gS}^{-1})+\frac{\kappa^2}{\alpha_{\pi S}}}{1+\alpha_{gS}^{-1}+\frac{\kappa^2}{\alpha_{\pi S}}}\right) \geq 1. \qquad (4.4)$$

Complete convergence in financing requirements is required only if $\kappa=1$. In that case, a national central bank delivers the optimal inflation rate as the failure to internalize the government budget constraint exactly offsets the self-defeating incentive to boost employment through unanticipated inflation. Hence, the potential benefits of different monetary arrangements in the union are zero since monetary arrangements outside the union are already optimal. If $\kappa>1$, however, the inflation rate is too low under a national central bank. By making the ECB less inflation adverse than society, welfare gains can be reaped. These gains can offset the costs of imperfect convergence. Indeed, the left-hand side of (4.4) exceeds unity so that perfect convergence is not required.

For $\kappa<1$, the maximum ratio of the financing requirements, for which an EMU is still feasible, is (see Appendix C)

$$\left(\frac{\tilde{K}_n}{\tilde{K}_1}\right)^{max} = \left(\frac{1+\alpha_{gS}^{-1}+\frac{\kappa^2}{\alpha_{\pi S}}}{(2\kappa-1)(1+\alpha_{gS}^{-1})+\frac{\kappa^2}{\alpha_{\pi S}}}\right) > 1, \text{ if } (2\kappa-1)(1+\alpha_{gS}^{-1})+\frac{\kappa^2}{\alpha_{\pi S}}>0, \qquad (4.5)$$

and $(\tilde{K}_n/\tilde{K}_1)^{max}=\infty$, otherwise. The allowed divergence of financing requirements increases if money holdings fall. For κ small enough (in particular, if $\kappa=0$), it is always possible to find a price-stability weight of the ECB for which all countries benefit -- irrespective of international differences in financing requirements. In that case, therefore, adjustments in monetary institutions suffice to make the EMU feasible and no convergence in fiscal and structural policy is required. Intuitively, if $\kappa<1$, the actual inflation rate under national policymaking exceeds the optimal inflation rate. If money holdings become smaller, inflation yields less seigniorage. Accordingly, the optimal inflation rate declines even further below the inflation rate under national policymaking. This provides more scope for an ECB with properly adjusted preferences to improve on the price-stability performance of a national central bank. Indeed, a more conservative ECB takes away the need to impose restrictions on fiscal and structural policies. Hence, a more conservative ECB and convergence requirements on fiscal and structural policies are substitutes.

Monetary union as a way towards independent monetary policy

The EMU might be a way not only to change the preferences of the monetary authorities, but also to decentralize monetary policy. In particular, with national policymaking, central banks may be under the control of the government. These dependent central banks thus internalize the

government budget constraint. The ECB, in contrast, is likely to be independent and involved in a Nash game with the fiscal authorities in the union, so that it does not take into account the government budget constraints. Then, an EMU is feasible if inflation after joining the EMU with an independent CB is at least as close to its social optimum as it is with national decisionmaking by a dependent central bank:

$$\left(\left(\frac{\frac{1}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)\left(\frac{\tilde{K}_A}{\tilde{K}_i}\right)-\left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)\right)^2 \le \left(\left(\frac{\frac{\kappa+1}{\alpha_{\pi S}}}{1+\frac{\kappa(\kappa+1)}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)-\left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)\right)^2, \qquad (4.6)$$

where the first term on the right hand side is the inflation rate (divided by K_i) effectively selected by a fiscal authority who has control over domestic monetary policy (see Beetsma and Bovenberg, 1995).

First, we investigate convergence requirements if the inflation weight of the ECB can not be adjusted ($\alpha_{\pi M}=\alpha_{\pi S}$). In this case, countries must be sufficiently disciplined compared to the rest of the union to find it in their interests to join the union. In particular, the maximum relative deviation of the individual financing requirement from the average that allows an undisciplined country to benefit from the union is given by (see Appendix D):

$$\left(\frac{\tilde{K}_n}{\tilde{K}_A}\right)^{max} = \frac{\left(1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}\right)\left(1+\frac{\kappa(\kappa+1)}{\alpha_{\pi S}}+\alpha_{gS}^{-1}\right)}{\left(1+\frac{\kappa}{\alpha_{\pi S}}+\alpha_{gS}^{-1}\right)\left((\kappa-1)(1+\alpha_{gS}^{-1})+\frac{\kappa^2(\kappa+1)}{\alpha_{\pi S}}\right)}. \qquad (4.7)$$

Countries with a higher financing requirement than given by (4.7) stay out of the union because they find the inflation rate in the union too low as the common central bank fails to internalize their substantial seigniorage needs. Appendix E shows that there exists a unique value, say κ^*, of $\kappa>1$ for which $(K_n/K_A)^{max}=1$. For $\kappa>\kappa^*$, an EMU is not feasible, even if financing requirements coincide. The reason is that with large money holdings an independent central bank produces higher welfare losses than a dependent central bank even in a closed economy with national decisionmaking (see also Beetsma and Bovenberg, 1995). Intuitively, with large money holdings, seigniorage revenues are relatively important so that the optimal inflation rate is relatively high. The independent central bank, however, fails to internalize the social value of seigniorage in providing public revenues and thus sets the inflation rate at a level that is much too low. This distortion, which produces too low an inflation rate, dominates the distortion due to the inflation bias under a dependent central bank associated with self-defeating incentives to use unanticipated inflation to boost employment.

Just as undisciplined countries, the more disciplined countries may not want to enter the

union. Their fear, however, is that inflation is too high in the union. In particular, the most disciplined country enters only if the average financing requirement, $\tilde{K}_A$, does not exceed the following upper bound (see Appendix D):

$$\left(\frac{(\kappa+1)(1+\alpha_{gS}^{-1})+\frac{\kappa(\kappa+1)}{\alpha_{\pi S}}}{1+\alpha_{gS}^{-1}+\frac{\kappa(\kappa+1)}{\alpha_{\pi S}}} \right) \tilde{K}_1 > \tilde{K}_1. \tag{4.8}$$

If κ approaches zero, financing requirements must converge completely from the perspective of the most disciplined country. The reason is that the seigniorage motive for inflation, which a dependent central bank internalizes, vanishes. Hence, making a central bank independent does not help in reducing the inflation bias of monetary policy. Consequently, no country with a lower than average financing requirement wants to enter the union: the higher financing requirement in the rest of the union raises inflation while decentralizing monetary policy does not produce lower inflation. Overall, inflation rises, thereby diverging further from its optimum.

To summarize, an EMU requires sufficient convergence of financing requirements in order to induce both the most and the least disciplined countries to join the union. How much financing requirements can diverge from the average depends on money holdings. For small money holdings, the more disciplined countries are unlikely to join because a monetary union is likely to increase the inflation bias of monetary policy. For large money holdings, in contrast, the least disciplined countries decline to enter as an independent ECB ignores their seigniorage needs.

The feasibility of an EMU is enhanced if the price stability weight of the ECB can diverge from that of society. The maximum ratio of the largest and the smallest financing requirement for which one can find a price stability weight for the ECB so that all countries benefit from joining the union is (see Appendix F),

$$\left(\frac{\tilde{K}_n}{\tilde{K}_1} \right)^{max} = \left(\frac{(\kappa+1)(1+\alpha_{gS}^{-1})+\frac{\kappa^2(\kappa+1)}{\alpha_{\pi S}}}{(\kappa-1)(1+\alpha_{gS}^{-1})+\frac{\kappa^2(\kappa+1)}{\alpha_{\pi S}}} \right) > 1, \text{ if } (\kappa-1)(1+\alpha_{gS}^{-1})+\frac{\kappa^2(\kappa+1)}{\alpha_{\pi S}}>0, \tag{4.9}$$

and $(\tilde{K}_n/\tilde{K}_1)^{max}=\infty$, otherwise. Provided financing requirements are sufficiently close, one can find a price stability weight of the central bank on which all participants agree. The convergence requirements become less severe if money holdings, κ, decline. Intuitively, with small money holdings, the social value of inflation in providing seigniorage is only small. Hence, the inflation rate with national decisionmaking by a dependent central bank is much too high as the self-defeating incentive to stimulate employment dominates the seigniorage motive. With sub-optimal monetary institutions outside the EMU, a conservative ECB can provide a much better performance

in guaranteeing price stability.

With small money holdings, there is a trade-off between, on the one hand, making the ECB more conservative, and, on the other hand, requiring more convergence. In particular, if the ECB cannot be made more conservative than society, financing requirements need to converge in order to convince the more disciplined countries to join the union (see expression (4.8)). However, if the ECB can be made sufficiently conservative, convergence requirements are not needed (see (4.9) with a small value for κ).

Asymmetric initial monetary arrangements

In the previous subsection, we assumed that all national central banks are dependent. In practice, however, some potential participants are likely to feature more independent and conservative central banks than others. The Bundesbank, for example, is known to be more independent and conservative than the Italian central bank. Therefore, we consider the case in which one country, say Germany, has an independent central bank with the optimal degree of inflation aversion before it joins the EMU. Hence, for Germany to be willing to participate, the ECB's price-stability weight should be given by (4.2) so that the ECB delivers the optimal inflation rate from the point of view of Germany.

In contrast to Germany, all other potential participants feature a dependent central bank with price stability weight $\alpha_{\pi S}$. Moreover, their financing requirements exceed that of Germany ($\tilde{K}_1 \leq \tilde{K}_2 \leq .. \leq \tilde{K}_n$, so that Germany is country 1). In that case, some country i, say Italy, is only willing to enter a "Germany-dominated" EMU if

$$\left(\frac{\kappa}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)\left(\frac{\tilde{K}_i-\tilde{K}_1}{\tilde{K}_i}\right) \leq \left(\left(\frac{\kappa+1}{1+\frac{\kappa(\kappa+1)}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right) - \left(\frac{\kappa}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)\right). \qquad (4.10)$$

Italy is more willing to participate the smaller is the relative difference between $\tilde{K}_1$ and $\tilde{K}_i$. Intuitively, the closer the financing requirements of Italy and Germany are, the closer the optimal inflation weight of Italy is to that of Germany (and thus of the ECB). This again emphasizes the importance of convergence in financing requirements for an EMU to be feasible. Italy's willingness to participate increases if seigniorage revenues become less important as indicated by a small value for κ. For κ close enough to zero, an EMU is always preferable for Italy, no matter how large its financing requirement is. Intuitively, the benefits of joining the EMU, namely reducing the self-defeating incentive to boost employment under discretion, dominate the costs, namely the failure of the ECB to meet the specific seigniorage needs of Italy.

5. Externalities in an EMU

This section studies the situation after the EMU has been formed. In particular, it analyses how a larger financing requirement in a particular country affects the other member countries of the union. These spillovers, which originate in the common inflation rate set by the ECB, in principle provide a case for some kind of coordination or surveillance of national fiscal and structural policies within a monetary union.

The externalities are found by differentiating V_i^E with respect to K_j:

$$\frac{\partial V_i^E}{\partial \tilde{K}_j} = \frac{1}{n}\left(\frac{\frac{1}{\alpha_{\pi M}}\left(\frac{\alpha_{\pi S}}{\alpha_{\pi M}}-\kappa\right)}{\left(1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}\right)^2}\right)\tilde{K}_i + \frac{1}{n}\left(\frac{\frac{\alpha_{\pi S}}{\alpha_{\pi M}^2}+\frac{\kappa^2}{\alpha_{\pi M}^2(1+\alpha_{gS}^{-1})}}{\left(1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}\right)^2}\right)\left(\tilde{K}_A-\tilde{K}_i\right). \qquad (5.1)$$

If initial financing requirements coincide, the sign of the spillover depends only on whether the ECB is sufficiently conservative from a social point of view. In particular, if the ECB is not conservative enough (i.e. $\alpha_{\pi M}<\alpha_{\pi S}/\kappa$), a marginal increase in the financing requirement imposes an adverse spillover on other countries. The reason is that initial inflation is too high because the ECB does not attach sufficient weight to price stability. A larger financing requirement in one of the member countries induces the ECB to raise inflation even further, thereby imposing a first-order loss on the other members of the union. The spillover effects vanish if monetary arrangements are optimal (i.e. $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$). Thus, the case for surveillance of fiscal and structural policies rests on suboptimal monetary arrangements. Indeed, restrictions on national fiscal and structural policies act as indirect instruments to deal with imperfections in the conduct of monetary policy.

The case of a disciplined member country, which features a low financing requirement, illustrates how surveillance of fiscal and structural policies can substitute for a properly designed central monetary institution. Such a disciplined country can protect itself against undisciplined policies in the rest of the union in two ways. One way is to set the price stability weight of the ECB according to (4.2) so that the ECB is sufficiently conservative. In that case, the inflation rate in the EMU is optimal from the point of view of the disciplined country. Hence, a marginal increase in inflation due to a larger foreign financing requirement does not generate any first-order effect on domestic welfare.

An alternative way for the disciplined country to deal with adverse spillovers is to increase fiscal discipline and reduce labor market distortions in the rest of the union. This can be illustrated with the case in which the price stability weight of the ECB coincides with the optimal weight under national policy making, i.e. $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$. If monetary policy is thus optimal 'on average', the spillover is determined by the second term at the right-hand side of (5.1). Thus, whereas disciplined countries featuring a less than average financing requirement suffer a negative externality from a higher financing requirement abroad, undisciplined countries with a relatively high financing requirement profit if the other countries raise their financing requirement. Intuitively, since the

monetary arrangements are attuned to domestic circumstances, each country wants other countries to become more like itself. From the perspective of a disciplined country, for example, inflation is too high in union. Therefore, it dislikes everything that raises inflation further, including an increase in the financing requirement in the rest of the union.

The disciplined country becomes more interested in surveillance of foreign policies, the more monetary arrangements diverge from what it would consider optimal. The case in which the price stability weight of the ECB coincides with that of society illustrates this. The spillover can then be written as follows:

$$\frac{\partial V_i^E}{\partial \tilde{K}_j} = \frac{1}{n}\left(\frac{\frac{1}{\alpha_{\pi S}} + \frac{\kappa^2}{\alpha_{\pi S}^2(1+\alpha_{gS}^{-1})}}{\left(1+\frac{\kappa}{\alpha_{\pi S}}+\alpha_{gS}^{-1}\right)^2}\right)\tilde{K}_A - \frac{1}{n}\left(\frac{\left(\frac{\kappa}{\alpha_{\pi S}(1+\alpha_{gS}^{-1})}\right)}{1+\frac{\kappa}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)\tilde{K}_i. \qquad (5.2)$$

The externality depends on the relative financing requirement but also on real money holdings. If money holdings are relatively small (i.e. $\kappa<1$), disciplined countries with a lower than average financing requirement ($K_i<K_A$) unambiguously suffer from a higher financing requirement abroad.[11] The lower real money holdings are, the less efficient monetary arrangements become from the point of view of these countries. These monetary imperfections produce larger adverse spillovers associated with less disciplined policies abroad.

Expression (5.2) indicates also that externalities are worse for the most disciplined countries. The reason is that these countries prefer a rather low community-wide inflation rate as their financing needs are relatively low. Hence, they suffer most from the boost to inflation associated with larger financing requirements abroad. These results suggest that countries with the most efficient tax systems, the lowest public debt and the most flexible labor markets (i.e., countries with the lowest financing requirements) are most interested in strict surveillance by the European Commission of fiscal and structural policies in other countries.

6. Conclusions

This paper has explored the interaction between monetary policy and other macroeconomic policies in the EMU. Modelling an imperfect world with distortionary taxes, labor-market imperfections, and imperfect commitment, we established a case for entrance requirements into the EMU involving convergence of not only public debt but also labor market institutions and public

[11] If moneyholdings are large enough (in particular, if $\kappa>1$), countries with a financing requirement above average (i.e. $K_i>K_A$) benefit from an increase in foreign financing requirements. From the perspective of these countries, inflation is not high enough to meet their seigniorage needs. Hence, a higher inflation rate boosting seigniorage is in the interests of these countries.

spending. The case for convergence criteria originates in the interaction between an ECB lacking commitment and fiscal and structural policies lacking instruments to eliminate all market imperfections. Within this framework, we showed how national policies can exert spillover effects on other member states by affecting the inflation rate in the EMU. These externalities provide arguments in favor of surveillance of national policies once an EMU has been established.

An important theme of the paper is that properly designing monetary institutions by adjusting the preferences of the ECB may substitute for entrance requirements and surveillance involving other policies and institutions. In this respect, an important area for future research is to incorporate stochastic shocks, which give rise to a trade-off between flexibility and credibility (Laskar, 1989; Lohmann, 1992). In particular, distorting policy preferences, while yielding benefits in terms of enhanced credibility of low-inflation policies, would become costly in terms of stabilizing shocks. A similar trade-off would apply to constraints on fiscal policy: convergence and surveillance of fiscal policy may harm stabilization policy. Hence, it would be interesting to explore in more depth what determines the optimal combination of, on the one hand, adjusting policy preferences of the ECB, and, on the other hand, constraining national fiscal policies.

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Technical appendices

A: Welfare loss is one-one related to deviation of inflation from the socially optimal rate.

We show that in making welfare comparisons, it suffices to compare deviations of inflation from the socially optimal inflation rate.

In all equilibria the relationship between total taxation (the sum of explicit and implicit taxes) and the government spending gap is $\tilde{g}-g=\alpha_{gS}^{-1}(\tau+\tilde{x})$. Using this relationship, we have that,

$$\tau+\tilde{x} = (1+\alpha_{gS}^{-1})^{-1} (\tilde{K}-\kappa\pi), \tag{A.1}$$

$$\tilde{g}-g = \left(\frac{\alpha_{gS}^{-1}}{1+\alpha_{gS}^{-1}} \right) (\tilde{K}-\kappa\pi). \tag{A.2}$$

Substitution of (A.1) and (A.2) into society's welfare loss function yields,

$$V_S(\pi) = \frac{1}{2} \left(\alpha_{\pi S}\pi^2+(1+\alpha_{gS}^{-1})^{-1} (\tilde{K}-\kappa\pi)^2 \right). \tag{A.3}$$

This expression is mimimised when the inflation rate is at its social optimum,

$$\pi^* = \left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}} \right) \tilde{K}. \tag{A.4}$$

Using the definition of π^* it is easy to see that $V_S(\pi^*-\epsilon)=V_S(\pi^*+\epsilon)$ for all ϵ. This completes the proof.

B: Proof of (4.2).

Because the trade-off between taxes and the government spending gap is always optimal, society i's optimal ECB inflation weight follows upon equating inflation under an EMU with the socially optimal inflation rate,

$$\left(\frac{\frac{1}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}} \right) \tilde{K}_A = \left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}} \right) \tilde{K}_i, \tag{B.1}$$

and solving for $\alpha_{\pi M}$.

C: Proofs of (4.4) and (4.5).

An EMU is feasible (eq.(4.3)) if and only if, for i=1,..,n,

$$\left(\beta(\tilde{K}_A/\tilde{K}_i) - \gamma\right)^2 \leq (\delta - \gamma)^2, \tag{C.1}$$

where $\beta \equiv \left(\frac{\frac{1}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}} \right)$, $\gamma \equiv \left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}} \right)$, $\delta \equiv \left(\frac{\frac{1}{\alpha_{\pi S}}}{1+\frac{\kappa}{\alpha_{\pi S}}+\alpha_{gS}^{-1}} \right)$. Let $\tilde{K}_1 \leq .. \leq \tilde{K}_n$ as in the main text.

C.1: Proof of (4.4).

This is the case of $\kappa>1$. From (C.1) we have that country i is prepared to participate in an EMU if and only if (note that $\gamma>\delta$ if $\kappa>1$),

$$\delta-\gamma \leq \beta(\tilde{K}_A/\tilde{K}_i)-\gamma \leq \gamma-\delta. \tag{C.2}$$

The conditions for an EMU to be feasible ((C.2), i=1,..,n) can be combined to the following two:

$$\beta(\tilde{K}_A/\tilde{K}_n) \geq \delta \text{ and } \beta(\tilde{K}_A/\tilde{K}_1) \leq 2\gamma-\delta. \tag{C.3}$$

Define $\alpha_{\pi M}^U$ and $\alpha_{\pi M}^L$ as the values of $\alpha_{\pi M}$ for which the first and second expression in (C.3) are met with equality, respectively. Hence,

$$\alpha_{\pi M}^U = \left(\alpha_{\pi S}+\frac{\kappa}{1+\alpha_{gS}^{-1}}\right)\left(\frac{\tilde{K}_A}{\tilde{K}_n}\right) - \frac{\kappa}{1+\alpha_{gS}^{-1}}, \tag{C.4}$$

$$\alpha_{\pi M}^L = \left(\frac{\left(1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}\right)\left(1+\frac{\kappa}{\alpha_{\pi S}}+\alpha_{gS}^{-1}\right)}{\left(1+\alpha_{gS}^{-1}\right)\left(\left(\frac{2\kappa-1}{\alpha_{\pi S}}\right)(1+\alpha_{gS}^{-1})+\frac{\kappa^2}{\alpha_{\pi S}^2}\right)} \right)\left(\frac{\tilde{K}_A}{\tilde{K}_1}\right) - \frac{\kappa}{1+\alpha_{gS}^{-1}}. \tag{C.5}$$

Then, $\alpha_{\pi M}^U$ is the upperbound on $\alpha_{\pi M}$ above which an EMU is not feasible, while $\alpha_{\pi M}^L$ is the lowerbound on $\alpha_{\pi M}$ below which an EMU is not feasible. An EMU is feasible if and only if $\alpha_{\pi M}^U \geq \alpha_{\pi M}^L$ and the set of ECB weights which leaves each country at least as well off as staying out of the EMU is $[\alpha_{\pi M}^L, \alpha_{\pi M}^U]$. Note that $\alpha_{\pi M}^U$ is decreasing in $\tilde{K}_n$ and that $\alpha_{\pi M}^L$ is decreasing in $\tilde{K}_1$. The maximum ratio $(\tilde{K}_n/\tilde{K}_1)^{max}$ then follows upon equating the expressions (C.4) and (C.5) for $\alpha_{\pi M}^U$ and $\alpha_{\pi M}^L$, respectively.

C.2: Proof of (4.5).

This is the case of $\kappa<1$. We follow the same line of reasoning as in the proof of (4.4). The conditions for an EMU to be feasible can be combined to the following two (note that now $\gamma<\delta$):

$$2\gamma-\delta \le \beta(K_A/K_n) \text{ and } \beta(K_A/K_1) \le \delta. \tag{C.6}$$

The first expression gives the upperbound $\alpha_{\pi M}^{U}$ and the second expression gives the lowerbound $\alpha_{\pi M}^{L}$:

$$\alpha_{\pi M}^{L} = \left(\alpha_{\pi S}+\frac{\kappa}{1+\alpha_{gS}^{-1}}\right)\left(\frac{\tilde{K}_A}{\tilde{K}_1}\right) - \frac{\kappa}{1+\alpha_{gS}^{-1}}, \tag{C.7}$$

$$\alpha_{\pi M}^{U} = \left(\frac{\left(1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}\right)\left(1+\frac{\kappa}{\alpha_{\pi S}}+\alpha_{gS}^{-1}\right)}{\left(1+\alpha_{gS}^{-1}\right)\left(\left(\frac{2\kappa-1}{\alpha_{\pi S}}\right)(1+\alpha_{gS}^{-1})+\frac{\kappa^2}{\alpha_{\pi S}^2}\right)}\right)\left(\frac{\tilde{K}_A}{\tilde{K}_n}\right) - \frac{\kappa}{1+\alpha_{gS}^{-1}}. \tag{C.8}$$

Equating the right hand sides of (C.7) and (C.8) yields the maximum ratio (4.5).

D: Proofs of (4.7) and (4.8).

An EMU is feasible (eq.(4.6)) if and only if, for i=1,..,n,

$$\left(\beta(\tilde{K}_A/\tilde{K}_i) - \gamma\right)^2 \le (\delta - \gamma)^2, \tag{D.1}$$

where where $\beta \equiv \left(\frac{\frac{1}{\alpha_{\pi M}}}{1+\frac{\kappa}{\alpha_{\pi M}}+\alpha_{gS}^{-1}}\right)$, $\gamma \equiv \left(\frac{\frac{\kappa}{\alpha_{\pi S}}}{1+\frac{\kappa^2}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)$, $\delta \equiv \left(\frac{\frac{\kappa+1}{\alpha_{\pi S}}}{1+\frac{\kappa(\kappa+1)}{\alpha_{\pi S}}+\alpha_{gS}^{-1}}\right)$.

Note that $\delta>\gamma$. Let $K_1 \le .. \le K_n$, as in the main text. From (D.1) we have that country i is prepared to participate in an EMU if and only if,

$$\gamma-\delta \le \beta(\tilde{K}_A/\tilde{K}_i)-\gamma \le \delta-\gamma. \tag{D.2}$$

These conditions for an EMU to be feasible ((D.2), i=1,..,n) can be combined to the following two:

$$2\gamma-\delta \le \beta(K_A/K_n) \text{ and } \beta(K_A/K_1) \le \delta. \tag{D.3}$$

Equation (4.7), the upperbound on K_n/K_A follows by setting the first expression in (D.3) to equality. Similarly, the upperbound on K_A from country 1's perspective follows by setting the second expression in (D.3) to equality.

E: Proof that there is a unique $\kappa(>1)$ such that $(K_n/K_a)^{max}=1$.

Set the right hand side of (4.7) equal to one. This equation can be reduced to

$$f(\kappa) \equiv (\kappa-2)(1+\alpha_{gS}^{-1})+(\kappa^3-2\kappa)/\alpha_{\pi S} = 0. \tag{E.1}$$

If $\kappa \leq 1$, the left hand side of (E.1) is negative, while if κ is large enough, the left hand side of (E.1) is positive. Finally, upon differentiating we see that $f'(\kappa)>0$, if $\kappa \geq 1$, which completes the proof.

F: Proof of (4.9).

We follow the same reasoning as in appendix C. Let $K_1 \leq .. \leq K_n$ as in the main text. The conditions for feasibility of an EMU can be combined to the following two:

$$2\gamma-\delta \leq \beta(K_A/K_n) \text{ and } \beta(K_A/K_1) \leq \delta, \tag{F.1}$$

where β, γ and δ are defined as in appendix D. Setting the first expression in (F.1) to equality gives the upperbound $\alpha_{\pi M}^{U}$ on $\alpha_{\pi M}$, while setting the second expression in (F.1) to equality gives the lowerbound $\alpha_{\pi M}^{L}$. Upon equating $\alpha_{\pi M}^{U}$ and $\alpha_{\pi M}^{L}$ we derive (4.9).